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W-6353

LEAD ATTACHMENT AND ENCAPSULATION TECHNIQUES FOR THIN FILM MICROCIRCUITS

TECHNICAL DOCUMENTARY REPORT NO. ESD-TDR-64-630

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P. N. Everett

Prepared for

DIRECTORATE OF COMPUTERS
ELECTRONIC SYSTEMS DIVISION
AIR FORCE SYSTEMS COMMAND
UNITED STATES AIR FORCE
L. G. Hanscom Field, Bedford, Massachusetts

Project 708.0

Prepared by

THE MITRE CORPORATION
Bedford, Massachusetts
Contract AF 19(628)-2390

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ABSTRACT

The techniques described were developed for encapsulating experimental thin film circuits deposited on 0.5-inch square glass substrates. The encapsulation is epoxy, with final package dimensions of 0.6-inch square x .125-inch thick. Up to 32 ribbon leads emerge, on .050 centers, arranged on the periphery of the package. A factor complicating the encapsulation was the requirement that the leads emerge on the four edges of the unit. A molding process using silicone rubber molds, and a hypodermic filling arrangement was evolved.

REVIEW AND APPROVAL

This technical documentary report has been reviewed and is approved.

SEYMOUR JEFFERY
Major, USAF
Chief, Computer Division
Directorate of Computers

SECTION I

INTRODUCTION

This report describes techniques used in lead attachment and encapsulation for certain experimental thin film circuits being fabricated at The MITRE Corporation.

The circuits to be encapsulated are formed on 0.5-inch square glass micro-sheets with thicknesses between .008-inch and .030-inch. The resistors and conductors are vacuum deposited. The semi-conductor devices are in chip form, with their connections either bonded or soldered to the deposited conductors. External connection lands are arranged near the four edges of the glass, on .050-inch centers. A typical circuit is shown in Fig. 1.

Leads are put on these circuits and the circuits are encapsulated so that the completed modules can be attached to a multilayer, strip line, printed circuit board. The encapsulation provides mechanical and a certain amount of environmental protection. Lead lengths must be kept as short as possible in view of the high operating frequencies of the circuits.

The form of the multilayer printed circuit board had not been decided when the packaging program was initiated. However, it was thought that planar ribbon leads, designed for soldering, would provide a flexible design for connections to the board, and would also give a relatively simple package.

Earlier work* indicated that the deposited resistors and conductors were stable under nonhumid conditions, without hermetic sealing. Most of the

*Bell, J., Working Paper W-5265, The MITRE Corporation, Sept. 1962

semi-conductors are passivated, the remainder are prepackaged. Therefore, it was decided that an epoxy encapsulation would be adequate for environmental protection.

Since the epoxy is rigid, and its coefficient of expansion is different from glass, a resilient dielectric gel layer was placed between the circuit and the epoxy encapsulation. The gel has a very low dielectric loss, which might be important for such high-speed circuitry.

An example of the package developed is shown in Fig. 2. Clear epoxy was used to allow the circuit to be seen; generally, a blue epoxy is used. The dimensions of the plastic encapsulation are 0.6-inch square x .125-inch and are of gold plated beryllium copper .020-inch x .002-inch.

The following sections describe the processes involved in the packaging. The techniques for making the encapsulation molds are described in the appendix.

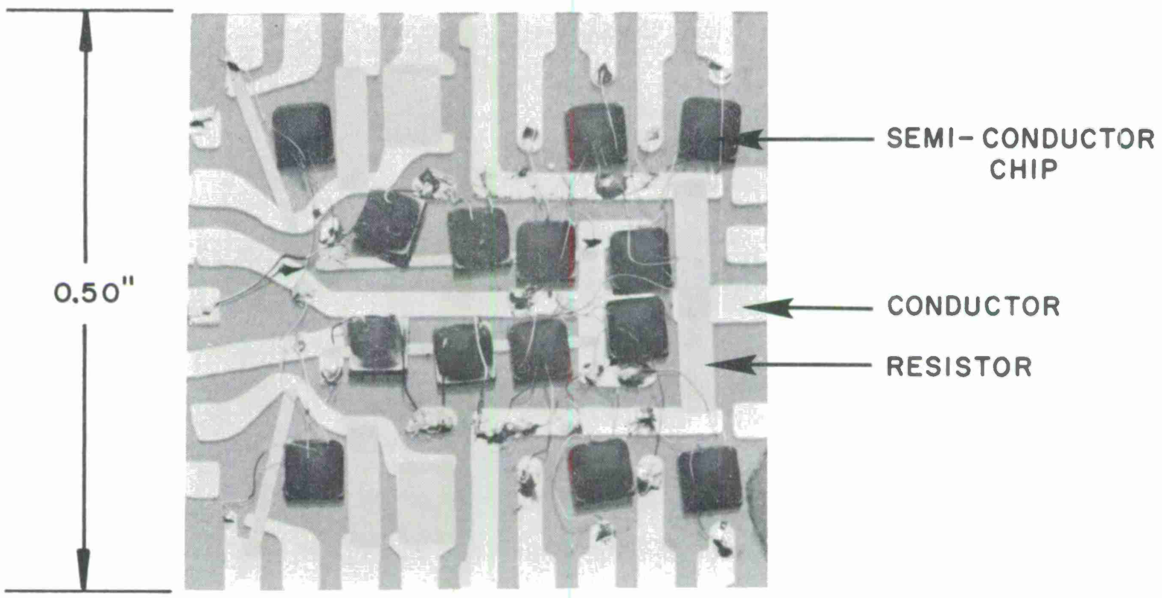

Fig. 1. 'OR' Gate Ready for Leads

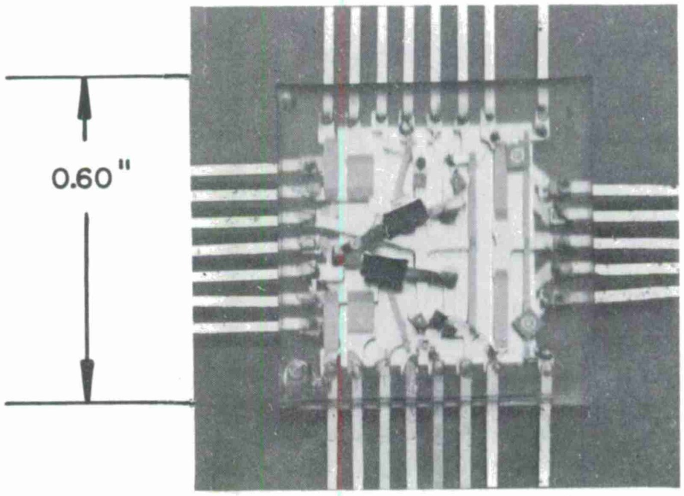

Fig. 2. Encapsulated Unit

SECTION II

TECHNIQUES

LEADS

The leads are etched in a comb pattern from beryllium copper sheet. The patterns are then gold plated and appear as in Fig. 3. The outer surrounding portion of the comb serves to hold the individual leads in the right location, while the inner ends are soldered to the circuit lands. All combs are made with a total of 36 leads. For any particular circuit not requiring the full complement of leads, the excess ones are cut with scissors.

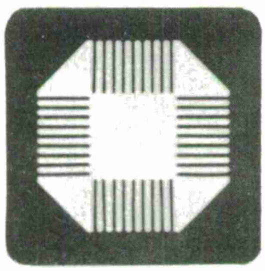

Fig. 3. Lead Comb Ready for Attachment

When the inner ends of the leads have all been soldered to the circuit lands, the excess material is clipped from the outer ends of the lands so that they become electrically independent. A special clipping machine has been made to cut the leads without distorting them or damaging the solder joint to the circuit. When the leads have been attached, the circuits appear as in Fig. 4.

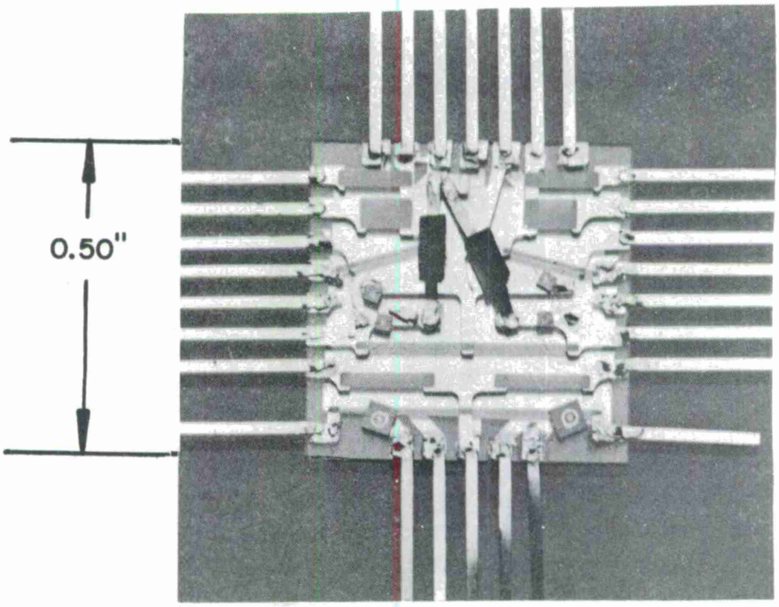

Fig. 4. 'Univer' Ready for Encapsulation

APPLICATION OF DIELECTRIC GEL

The circuits are supported by their leads on a slab of aluminum which has a channel cut a little wider than the glass substrate.

Dow Corning Sylgard #51 is mixed according to instructions (a two-part mix). Four drops of the gel are squeezed from an eye dropper onto each circuit. The liquid forms a smooth surfaced shallow mound over the circuit. Surface tension prevents it running over the edges. The gel is cured at 75 C overnight in an oven. It forms a sticky resilient layer. The gel is transparent, so the circuit can be visually inspected for damage.

EPOXY ENCAPSULATION

A pair of mold halves is shown in Fig. 5 with a completed unit is one-half of the mold. Also shown is the master for making the molds.

The middle white area of the mold halves consists of silicone rubber, which has a certain amount of resilience. This rubber area contains the molding cavity, the entry and overflow cavities, and the necessary gates between them. The cavities have slightly raised ridges around their edges to reduce flash, particularly between the leads.

The circuit, ready for encapsulation, is placed in the central cavity in one of the mold halves. The circuit is supported by the leads resting on the cavity edges. The circuit is carefully centered with the aid of a microscope. The microscope has a grid reticle in the eyepiece. The reticle appears as a .050-inch grid superimposed on the mold. The mold is first moved to line up the cavity sides on the grid, then the circuit is moved to line up the leads on the correct grid lines. The second half of the mold is laid on the first and the two clamped together with screws. The mold is then placed vertically in a vise with the missing corner uppermost.

Stycast 1264 (Emerson and Cuming, Inc.) epoxy is used if transparent encapsulation is required; otherwise opaque Stycast 2651 MM (Emerson and Cuming, Inc.) epoxy is used. While this can be obtained in black or most colors, sky blue is generally used.

The epoxy is mixed according to the manufacturer's instructions and is given a vacuum treatment to eliminate air bubbles. A disposable hypodermic syringe (#18 gauge needle) is filled with the epoxy, then the needle is inserted into the mold through the hole provided. Epoxy is slowly injected into the mold until the overflow cavity is half filled. The hypodermic is removed, and a wire plug inserted in the hypodermic hole.

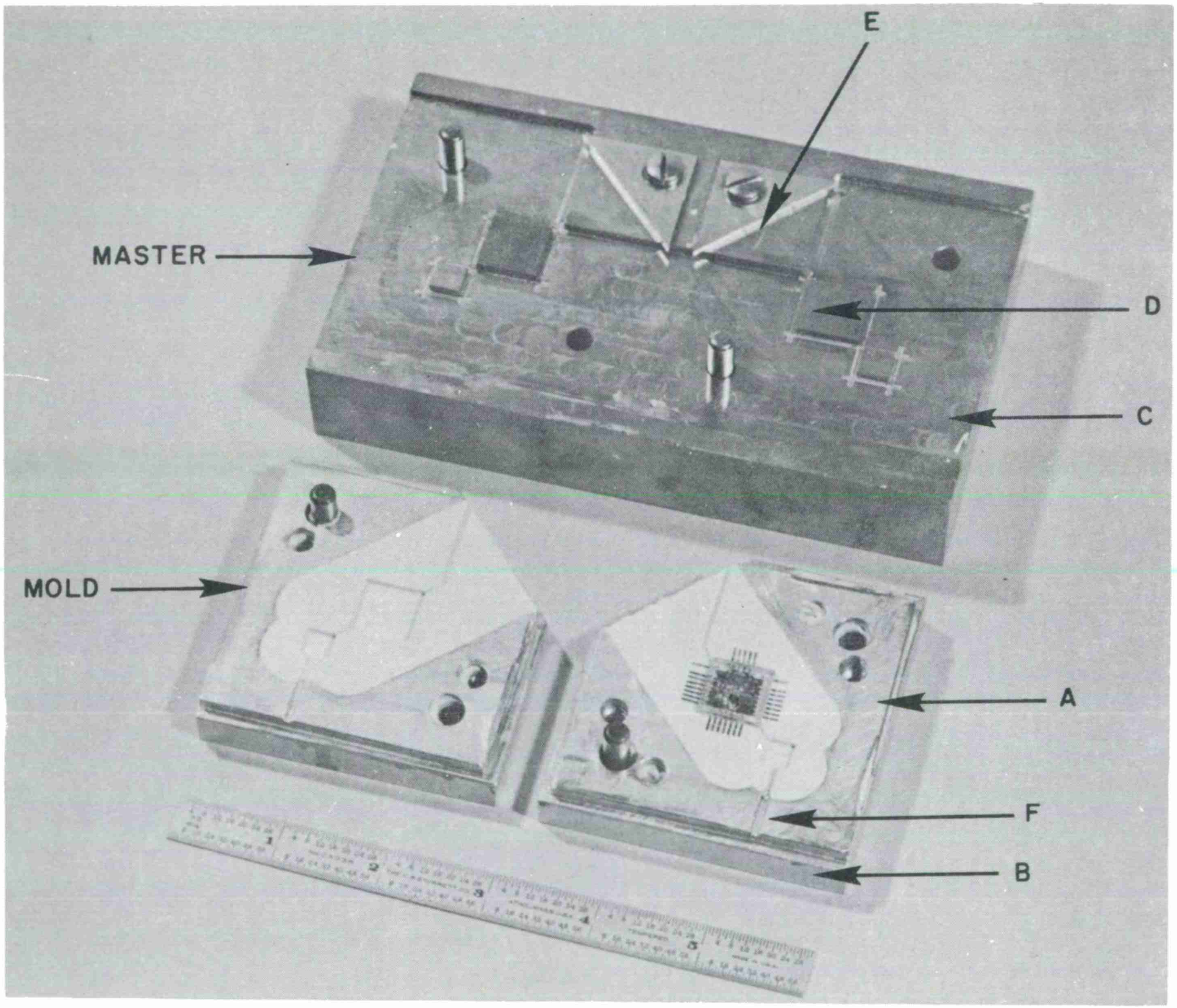

Fig. 5. Molding Forms

The mold is placed on a rack in an oven at 40 C and cured overnight. When cured, the mold is opened. The superfluous epoxy pieces are easily broken at the small gate sections. The molded encapsulation is shown in Fig. 5. The package is lifted out of the mold. Sometimes a very thin flash forms between the leads, but this flash can be easily removed with a pair of tweezers. The unit then appears as in Fig. 2.

Patrick N. Everett

Patrick Everett

APPENDIX

MOLD MAKING

Each half of a mold consists of two machined aluminum pieces (A and B in Fig. 5). Part A is 1/8-inch thick and is cut in the form of a template. Part B, 1/2-inch thick, has a 1/4-inch pin inserted and a 1/4-inch reamed hole. The rubber section of each half-mold is made with the aid of the mold master (C in Fig. 5).

The master is machined from brass. The two parts (D) which give the main cavity in the molds are removable inserts. This allows the encapsulation dimensions to be altered somewhat, if required, and the inserts can be polished to give high quality molding.

The silicone rubber is Eccosil 4850 (Emerson and Cuming, Inc.). It is mixed according to instructions and is given a vacuum treatment to remove air bubbles. If the rubber is required to stick to the plates A and B, Eccosil Primer 33 (Emerson and Cuming Inc.), is applied first and allowed to dry.

Two aluminum parts (A) are laid on the master, using the pins and holes as a guide; parts (E) on the master and the plates (A) then form an 1/8-inch high wall around the mold details on the master. The silicone rubber is poured over the mold details until the surface of the rubber is just over the tops of plates (A). Plates (B) are then pressed down on top and the excess rubber squeezed out between the plates.

The whole assembly is then cured in an oven at 40 C overnight. When cured, the half-molds are lifted from the master, the gates are cut in the rubber with a sharp knife, the two halves are then clamped together, and the hole (F) for the hypodermic entry is drilled.

Before use, the aluminum parts of the mold are painted with a solution of candle wax in xylene, to prevent any sticking of the epoxy. When a mold becomes worn out or damage, the rubber is stripped out and the metal parts are used again.

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DOCUMENT CONTROL DATA - R&D

(Security classification of title, body of abstract and indexing annotation must be entered when the overall report is classified)

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Microcircuits						
Printed Circuits						
Encapsulation						
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